Agricultural biomass as provisioning ecosystem service: quantification of energy flows

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Contact information
Maria Luisa Paracchini
Address: Joint Research Centre, Via Enrico Fermi 2749, TP 266, 21027 Ispra (VA), Italy
E-mail: luisa.paracchini@jrc.ec.europa.eu Tel.: +39 0332 78 9897

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Abstract

Agro-ecosystems supply provisioning, regulating and cultural services to human society. This study focuses on the agro-ecosystem provisioning services regarding the production of agricultural biomass. These services strongly respond to the socio-economic demands of human beings, and are characterised by an injection of energy in the ecosystems production cycle which is often exceeding the ecological capacity of the ecosystem, i.e. the overall ability of the ecosystem to produce goods and services linked to its bio-physical structure and processes that take place during the agricultural production. Agricultural production is identified as ecosystem service in widely recognised ecosystem service frameworks, but currently there is no clear agreement within the scientific and policy communities on how the ecological-socio-economic flow linked to this provisioning service should be assessed, beyond a mere accounting of yields. This study attempts to provide a new insight to this issue by proposing an approach based on the energy budget, which takes into consideration the energy needed by the ecosystem to supply the service. The approach is based on the concepts of Energy Return on Investment (EROI) and Net Energy Balance (NEB), and considers different bio-physical structures and processes of agro-ecosystems. The work is structured in three parts: the first aims at estimating inputs (machinery, seeds, fertilizers, irrigation, labour) in energy terms; the second at estimating biomass output in energy terms; the third to compare actual agricultural production with three reference scenarios encompassing a range of human input (no input – low input – high input scenarios). Results show that in general terms cereal and grassland systems have the largest energy gains (both in terms of EROI and NEB). Such systems are characterised by a lower economic value of their output compared to other producing systems such as fruits, which have lower energy gains but a higher embodied energy, which is recognized in the market as valuable. Comparison of actual production systems with the high input scenario confirms that current production in Europe is already highly intensive, and that increasing the energy input would not improve the efficiency of the conversion of such additional energy into biomass. Overall, the proposed approach seems a useful tool to identify which are the factors in the agricultural production process that could be modified to improve the energy efficiency in agricultural systems and the sustainability of their production. This study can be considered as a first step in the assessment of the total energy balance of the agro-ecosystem. In fact it deals with the quantification of energy regarding human inputs and the corresponding output and further analysis should address crucial issues such as the quality of the energy and the embodied energy in the plant production, which will help to better understand the complexity of the agro-ecosystems.